Irrigation Water Conveyance (ft)

Corrugated Metal Pipeline

Definition

A pipeline and appurtenances installed in an irrigation system.

Scope

This standard applies to circular corrugated metal pipe 48 in. in diameter or less and arched pipe with span and rise dimensions of 58 in. by 38 in. or less.

Purpose

To prevent erosion or loss of water quality or damage to land and to reduce water conveyance losses to make possible the proper management of irrigation water.

Condition where practice applies

All pipelines shall be planned and located to serve as integral parts of an irrigation water distribution or conveyance system designed to facilitate the conservation and management of soil and water resources on a farm or group of farms.

All areas served by the pipeline shall be suitable for use as irrigated land.

Water quality and quantity shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Design criteria

Friction losses. Friction head losses shall be no less than those computed by Manning Formula, with a coefficient of roughness 'n' as shown in Table 1 for circular pipe. Use Table 2 to determine 'n' value for arched pipe.

Table 1 - Manning 'n' for circular corrugated metal pipe

Dia. (in.)	Area (sq.ft.)	Corrugation Pattern and Construction Type								
		1-1/2" x 1/4"	2-2/3" x 1/2" 2/				3" x 1"			
		H 3/ 1/	H 1/	H 25% paved	A 3/ 1/	A 25% paved	H 1/	H 25% paved	A	A 25% paved
6	.20	.010								
8	.35	.013								
10	.55	.016								
12	.79		.011		.026					
15	1.23		.013		.025					
18	1.77		.014		.025					
21	2.41		.016		.025					
24	3.14		.017	.015	.025	.021				
30	4.91		.018	.016	.025	.021	.019	.018	.027	.023
36	7.07		.019	.017	.025	.021	.020	.019	.027	.023
42	9.62		.020	.019	.024	.021	.020	.019	.027	.023
48	12.57		.020	.020	.024	.021	.020	.020	.027	.023

1/ n values based on test results from St. Anthony Falls Hydraulic Laboratory, Minn.

2/ Some helical corrugation have depth of 7/16 in., use value for 1/2 in.

3/ H = helical, A = annular

Table 2 - Equivalent values for Arched Pipe for Selecting Manning n[1/]

Aluminum			Steel			
Size		Area (sq.ft.)	Size		Area (sq.ft.)	Diameter of Pipe of Equal Periphery (in.)
Span (in.)	Rise (in.)		Span (in.)	Rise (in.)		
17	13	1.2	18	11	1.1	15
21	15	1.7	22	13	1.6	18
24	18	2.3	25	16	2.2	21
28	20	2.9	29	18	2.8	24
35	24	4.4	36	22	4.4	30
42	29	6.5	43	27	6.4	36
49	33	8.4	50	31	8.7	42
57	38	11.3	58	36	11.4	48

1/ To determine n value for arched pipe, select equivalent circular pipe diameter and go to Table 1 to select n for appropriate corrugation configuration.

Capacity. The design capacity of the pipeline shall be based on whichever of the following criteria is greater:

1. The capacity shall be sufficient to deliver the volume of water required to make irrigation practical for use on the crop or crops to be irrigated.

2. The capacity shall be sufficient to provide an adequate irrigation stream for the methods of irrigation to be used.

Working pressure. All pipelines shall be designed for partial pipe flow except that reaches of pipe under pressure flow such as swag pipes shall have a maximum design working pressure as follows:

1. 20 ft. of head for annular and helical pipe with sealed seams and watertight couplings.

2. 30 ft. of head for helical pipe with welded seam, annular ends, and watertight couplings.

Head is to be measured from the flow line of the pipe.

Pipe with the seams not sealed may be used under partial flow conditions. Watertight couplings shall be used for this condition.

External load limit . Fill heights shall not exceed the maximum depths given in Tables 3, 4, and 5, for the gauge, size, and shape of pipe given.

Table 3 - Maximum depth of cover for steel corrugated circular pipe, H-20 loading 1/.

Corrugation Pattern			Specified Thickness (inches)					
1-1/2 X 1/4	2-2/3 X 1/2	3 X 1	.052	.064	.079	.109	.138	.168
			Equivalent Standard Gauge					
			18	16	14	12	10	8
Diameter (inches			Maximum depth of cover (feet)					
6 2/				200				
8 2/				90				
10 2/				51				
	12		98	119	145			
	15		58	69	83			
	18		41	47	55			
	21		32	36	41	51		
	24		27	30	33	40		
	27			24	28	33		
	30			24	25	29		
	36			21	22	24	26	
		36	31	25	39	48	57	67
	42			19	20	21	23	24
		42	26	25	31	36	42	48
	48			18	19	20	21	22
		48	23	20	26	30	34	38

1/ See West NTC Bulletin No. W210-4-30 June 29, 1984 for formula used to compute allowable height of fill with 5% pipe deflection.

2/ This diameter may not be available.

Table 4 - Maximum depth of cover for Aluminum Corrugated circular pipe, H-20 loading 1/.

Corrugation Pattern				Specified Thickness (inches)					
				.040	.060	.075	.105	.135	.164
1-1/2 X 1/4	2-2/3* X 7/16	2-2/3 X 1/2	3 X 1	Equivalent Standard Gauge					
				18	16	14	12	10	8
Diameter (inches)				Maximum depth of cover (feet)					
6				55	77				
8				33	43				
10				25	30				
	12				50	59	78		
	15				34	38	48		
	18				27	29	35		
	21				23	25	28		
	24				21	22	25	27	
	27				20	21	22	24	
		30				20	21	22	
			30		29	29	35	40	
		36				19	19	20	
			36		24	24	27	31	
		42					18	19	
			42		21	21	23	26	
		48					18	18	19
			48		20	20	21	23	24

1/ See West NTC Bulletin No. W210-4-30 June 29, 1984 for formula used to compute allowable height of fill with 5% pipe deflection; $E_{Al} = 10 \times 10^6$.

Table 5 - Maximum depth of cover for steel and aluminum corrugated arched pipe, H-20 loading.

Aluminum-helical & riveted 2-2/3 X 1/2				Steel					
Size Span X Rise (in.)		Gauge 1/	Maximum 2/ depth (ft.)	Size Span X Rise (in.)		2-2/3" X 1/2"		3" X 1"	
						Gauge	Max.Depth (ft) 2/	Gauge	Max.Depth (ft.) 2/
17	13	16	13	18	11	16	13		
21	15	16	13	22	13	16	12		
24	18	16	12	25	16	16	10		
28	20	14	11	29	18	16	9		
35	24	14	11	36	22	16	9		
42	29	12	10	43	27	16	7	16	12
49	33	12	10	50	31	14	7	16	12
57	38	10	9	58	36	12	7	16	12

1/ Gauges shown for information purposes only.

2/ Corner bearing pressures assumed to be 2 tons per square foot for maximum depths given. Maximum depth cover based on maximum 5% deflection. Re. U.S. Department of Commerce/Bureau of Public Roads, Corrugated Metal Pipe Culverts Structural Design Criteria and Recommended Installation Practice, U.S. Government Printing Office, June 1966, p. 14, 25.

Vents. Vents or air and vacuum-release valves shall be designed into the pipeline where needed.

Drainage and flushing . Provisions shall be made for completely draining the pipeline if a hazard is imposed by freezing temperatures or if drainage is specified for the job.

If required, drainage outlets shall be located at all low places in the line. These outlets may drain into dry wells or to points of lower elevation. Drainage and flushing points shall be located to minimize erosion potential and to minimize ponding of water at undesirable locations. If drainage cannot be provided by gravity, provisions shall be made to empty the line by pumping.

Outlets. Appurtenances for delivering water from a pipe system to the land, to a ditch, or to a surface pipe system shall be known as outlets. Outlets shall have the capacity to deliver the required flow:

1. To a point at least 6 in. above the highest field elevation.

2. To the hydraulic gradeline of a pipe or ditch.

Pipeline placement. Pipelines may be buried, placed on the ground, or above the ground.

Buried pipelines, which are subject to hazards such as traffic crossings, farm operations, freezing temperatures, or soil cracking, shall be placed deep enough to protect the pipeline. In hazardous situations the minimum cover shall be 1 ft., but in soils susceptible to deep cracking the minimum cover shall be 2 ft.

Onground pipelines shall be protected from hazards imposed by traffic crossings, farm operations, or other hazards.

Aboveground pipelines shall be adequately supported by vertical bents to prevent the pipe from moving to maintain proper grade and alignment. Spacing of vertical bents shall assure that neither the maximum beam stresses in the pipe span nor the maximum stress at the bent exceed design stress values.

Thrust control. Aboveground pipelines shall have the movement of each pipe length restrained by steel holddown straps at the pipe supports or by anchor blocks instead of normal pipe supports.

Joints and connections. All connections shall be designed to withstand the maximum working pressure of the pipeline without leakage and to leave the inside of the pipeline free of any obstruction.

Corrosion protection. All fittings, such as risers, ells, tees, and reducers, should be of similar metals. If dissimilar metals are used, the fittings shall be protected against corrosion. For example, separate dissimilar metals with a rubber or plastic insulator.

Bolts used to join galvanized steel must be galvanized, plastic coated, or otherwise protected to prevent galvanic corrosion. Bolts used to join aluminum, other than aluminum alloy bolts, must be galvanized, plastic coated, or otherwise protected to prevent galvanic corrosion.

When cathodic protection is required, joints shall be bridged to ensure continuous flow of current.

Interior protective coatings shall be provided when the pH of the water is less than, or greater than, the values shown in the following table:

Material	Water pH
Aluminized steel	<5-9<
Galvanized steel	<6-10<
Aluminum alloy	<4-10<

Hot dipped asphalt, asbestos bonded bituminous, or polymeric coated galvanized,or aluminized steel pipe shall be provided if the soil resistivity along any part of the pipeline is between 3000 and 4000 ohm-cm. Cathodic protection, in addition to the above coatings, shall be provided for galvanized steel pipe if the soil resistivity is less than 3000 ohm-cm. Aluminized steel pipe shall not be used when the soil resistivity is less than 3000 ohm-cm.

Galvanized or aluminized steel pipe shall be used when the soil resistivity is greater than 4000 ohm-cm, or aluminum alloy pipe may be used when the soil resistivity is greater than 500 ohm-cm.

Aluminum alloy pipe shall not be used when the soil resistivity is less than 500 ohm-cm or soil pH is less than 4 or greater than 9.

Cathodic protection. The total current required, the kind and number of anodes needed, and the expected life of the protection may be estimated as shown below.

The total cathode current required may be estimated from the formula:

$$I_t = C \left[\frac{A_i}{R_{e1}} + \frac{A_2}{R_{e2}} + \frac{A_n}{R_{en}} \right]$$

Where:

I_t = total current requirement in mA
A = surface area of pipe in square feet
R_e = soil resistivity in ohm-cm
C = a constant for a given pipe coating = 60

The kind of galvanic anode to be used depends on the resistivity of the soils in the anode bed location. If the resistivity of the anode bed is:

a. Less than the 2,000 ohm-cm, zinc anode, shall be used;
b. Between 2,000 and 3,000 ohm-cm, either zinc or magnesium anodes shall be used.

The number of anodes needed to protect the pipeline may be estimated by dividing the total cathode current requirement of the pipeline by the current output per anode.

Thus:

$N = I_t/I_m$ and $I_m = k/R$

Where:

N = number of anodes needed
I_t = total current requirement in mA
I_m = maximum anode current output in mA
k = constant for a given anode
R = soil resistivity of the anode bed in ohm-cm

The expected life of an anode, based on the use of 17 lb/ampere year for magnesium and 26 lb/ampere year for zinc and a utilization factor of 0.80, shall be computed as follows:

Magnesium.....$Y = 47W/i_o$
Zinc.....$Y = 31W/i_o$

Where:

Y = expected life in years
W = weight of anode in pounds
i_o = design anode current in mA = I_m unless resistors are used in anode circuit to reduce output

If resistors are used to reduce anode current output to increase service life, the number of anodes required shall be based on the regulated output of the anode rather than on the maximum output, I_m.

Preliminary soil-resistivity measurements to determine coating requirements and the approximate amount of cathodic protection needed, may be made before the trench is excavated. For this purpose, field resistivity measurements shall be made, and samples for laboratory analysis shall be taken at least every 400 feet along the proposed pipeline and at points where there is a visible change in soil characteristics. If a reading differs markedly from a

preceding one, additional measurements shall be taken to locate the point of change. Resistivity determinations shall be made at two or more depths in the soil profile at each sampling station; the lowest depth shall be the strata in which the pipe will be laid. The lowest value of soil resistivity found at each sampling station shall be used as the design value for that station.

After the pipe trench is excavated, a detailed soil-resistivity survey shall be made as a basis for final design of the coating and the required cathodic protection. At this time, resistivity measurements shall be made in each exposed soil horizon at intervals not exceeding 200 feet. The lowest value of soil resistivity found at each sampling station shall be used as the design value for that station. If design values for adjacent stations differ significantly, additional intermediate measurements shall be made.

Anodes. Anodes shall be at or below the bottom elevation of the pipeline if horizontally placed. Vertically placed anodes shall have a minimum distance of 3 feet between the ground surface and the top of the anode. Anodes shall not be placed in fill areas, and magnesium anodes must be placed a minimum distance of 10 feet from the pipeline.

The lead wire from the anode, or the header wire for multiple anode installations, shall be attached to the pipeline by cadwelding, thermowelding, or other similar processes. The area of damaged pipe coating and the weld shall then be covered with a coating equal in quality to that of the specified original pipe coating.

Abrasion protection. An interior asphalt coating and invert-paving shall be used where abrasion will be a problem.

Materials. All materials shall meet or exceed the minimum requirements indicated in "Specifications for Materials."

Plans and specifications. Plans and specifications for corrugated metal irrigation pipelines shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

Irrigation Water Conveyance

Corrugated Metal Pipeline Specifications

Installation

Buried pipelines. Pipe shall be laid to the lines and grades as shown on the drawings and/or as staked in the field, and shall be placed deep enough below the land surface to protect it from the hazards imposed by traffic crossings, farm operations, freezing temperatures, or soil cracking.

The trench bottom shall be uniformly excavated so that the full length of pipe contacts the bottom without bridging. Clods, rocks, and uneven spots that can cause nonuniform support shall be removed.

If trenches are excavated in soils containing rock or other hard material that might damage the pipe or coating material, the trenches shall be over excavated a minimum of 4 in. and then backfilled to grade with consolidated sand or fine earth bedding.

The trench at any point below the top of the pipe shall be only wide enough to permit the pipe to be easily placed and joined and to allow the initial backfill material to be uniformly placed under the haunches and along the sides of the pipe.

Provisions shall be made to assure safe working conditions if unstable soil, trench depth, or other conditions can be hazardous to personnel working in the trench. Trench banks more than 5 ft. high shall be shored, laid back to a stable slope, or equivalent protection shall be provided if personnel are exposed to danger.

Coated pipe shall be handled in a manner to prevent abrasion of the coating during transportation, placement, and backfilling. Pipe shall not be dropped or allowed to roll down skids without proper restraining ropes. If the pipe must be moved longitudinally along the trench, care shall be taken to assure that the pipe and the coating are not damaged. Pipe shall not be rolled or dragged on the ground. If the pipe is supported, the supports shall be of sufficient width and number and be padded, if necessary, to prevent damage to the coating. Damaged coating shall be repaired before backfilling.

Initial backfill for live loading. Hand, mechanical, or water packing methods shall be used where there is a potential for live loading. The initial backfill material shall be class I, II, III, or IV as described in Figure 1. Initial backfill material, as shown in Figure 2, shall be placed from the bottom of the trench to a depth of 0.7 of the pipe diameter for circular pipe. For arched pipe, the initial fill depth shall be as given in Table 6.

Figure 1:

INITIAL BACKFILL MATERIAL DESCRIPTION

Class of Select Initial Backfill Material	Description
I	Angular, 1- to 1/4-in. size, graded crushed stone with a maximum of 10% non-cohesive fines.
II	Coarse sands (>0.5 mm) and gravels with maximum particle size of 1 in. including sands and gravels containing a maximum of 12 % non-cohesive fines. Soil types GW, GP. SW, and SP are included in this class.
III	Fine sand and clayey gravels, including fine sands, sand-clay mixtures, and gravel-clay mixtures. Soil type GM, GC, SM, and SC are included in this class.
IV	Silt, silty clays, and clays, including inorganic clays and silts of medium plasticity and liquid limit. Soil types ML and CL are included in this class.

BACKFILL REQUIREMENTS FOR LIVE LOADING

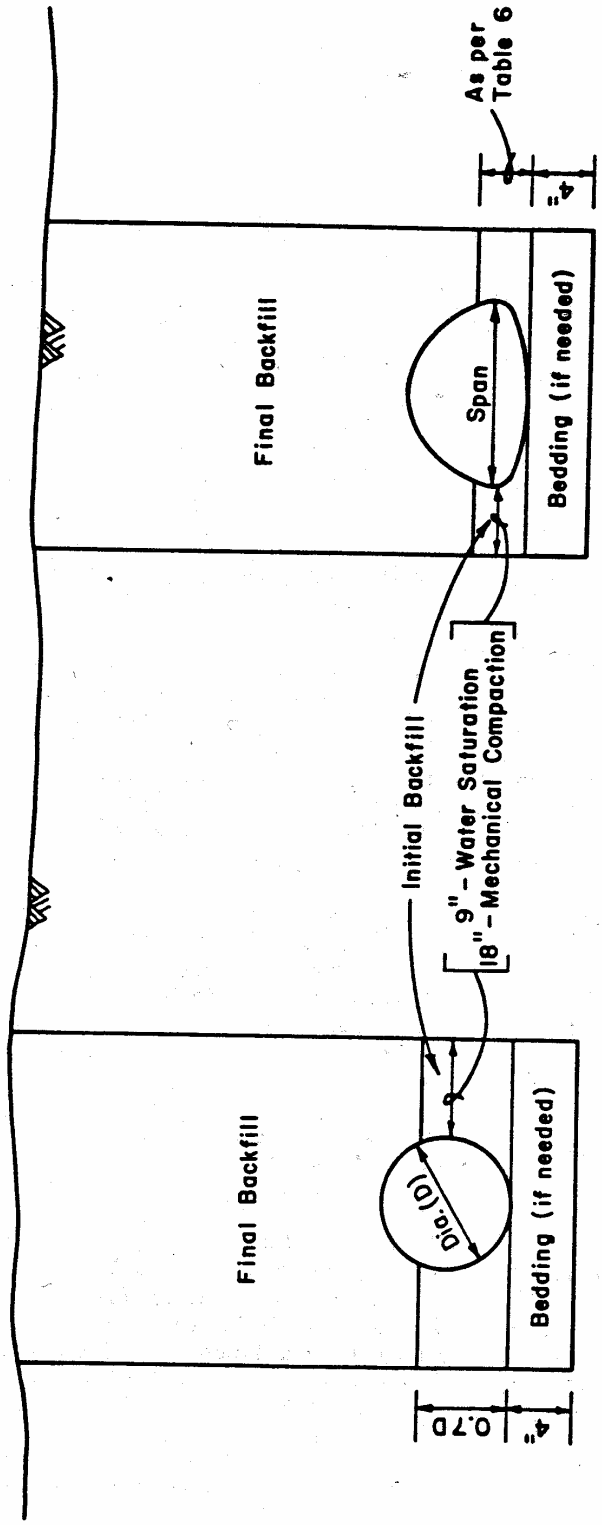

FIGURE 2

Table 6 - Depth of initial backfill for arched pipe.

Steel Pipe Span (in.)	Aluminum Pipe Span (in.)	Corrugations 2-2/3"x 1/2" (feet)	Corrugations 3"x 1" (feet)
18	17	0.4	-
22	21	0.4	-
25	24	0.4	-
29	28	0.5	-
36	35	0.5	-
43	42	0.6	0.8
50	49	0.7	0.9
58	57	0.8	1.0

All initial backfill material shall be free from rocks and hard earth clods larger than 3 in. in diameter. It shall not contain frozen material, sod, cinders, or earth containing a high percentage of organic material.

At the time of placement, the moisture content of the material shall be such that the required degree of compaction can be obtained with the backfill method to be used. The initial backfill material shall be placed so that the pipe will not be displaced, excessively deformed, or damaged.

If backfilling is done by hand or mechanical means, the initial fill shall be compacted firmly in 4 in. to 6 in. lifts around the pipe, as required in Figure 2 or Table 6, (to provide adequate lateral support to the pipe). Each lift shall be shoveled and tamped between the pipe and the side of the trench to provide satisfactory pipe support. Care shall be taken to assure that backfill is placed under the haunches of the pipe sufficiently to fill all voids and provide uniform bearing.

The GC and SC of Class III and all Class IV initial backfill material, shall be compacted to a density equal to or greater than the surrounding soil material.

If the water packing method is used, the pipeline shall first be filled with water. The initial backfill, before wetting, shall be of sufficient depth to insure a final depth of 0.7 of the pipe diameter for circular pipe or the depth required in Table 6 for arched pipe after consolidation. Water packing is accomplished by adding water to diked reaches of the trench in sufficient quantity to thoroughly saturate the initial backfill. The backfill shall then be vibrated sufficiently to fill all voids under the pipe. The amount of water used for consolidation shall be controlled to insure no pooling of excess water. After the backfill is saturated, the pipeline shall remain full until after the final backfill is made. The wetted fill shall be allowed to

dry until firm before beginning the final backfill. Water compaction shall be used only on soils that are well drained.

GM and SM of Class III soil material and Class IV soil material shall not be water compacted.

Final backfill. The final backfill material shall be soil or sand, free of hard earth clods larger than 3 in. in diameter or stones greater than 1 in. diameter, to a depth of 6 in. over the pipe. The remaining final backfill material shall be free of large rocks, frozen clods, and other debris greater than 3 in. in diameter. The material shall be placed and spread in approximately uniform layers so that there will be no unfilled spaces in the backfill. The backfill shall be placed to the level of the natural ground, or to the design grade required to provide the minimum depth of cover after settlement.

Rolling equipment shall not be used to consolidate the final backfill until the specified minimum depth of cover has been placed.

All special backfilling requirements of the pipe manufacturer shall be met.

Backfill for nonlive loading. In the situations where there is no potential for live loading, the "Initial backfill" criteria shall only apply to backfilling under the haunches of the pipe. The remaining backfill shall be according to "final backfill" criteria.

Aboveground pipelines. Concrete, timber or other pipe supports, and anchor and thrust blocks shall be constructed at the locations and to the dimensions shown on the drawings and/or as staked in the field.

Onground pipelines. Pipe shall be laid to the lines and grades shown on the drawings and/or as staked in the field. The ground shall be shaped so as to provide support. If there are rocks or objects that might damage the pipe coating, sand or fine soil shall be used as a base for the pipe.

Concrete, timber, or other anchors and thrust blocks shall be constructed at the locations, to the dimensions shown on the drawings, or as staked in the field or both.

Paint. All field welds and all exposed metal shall be thoroughly cleaned and painted with two coats of zinc dust-zinc oxide primer, Type III paint described in the Materials section of this Specification.

Any damaged polymer coating shall be thoroughly cleaned and painted with a polymer paint compatible with the pipe polymer coating in accordance with the recommendations of the manufacturer. The coatings shall be applied at a uniform thickness and in accordance with the recommendation of the manufacturer.

Joints and connections. All joints and connections shall be capable of withstanding the design maximum working pressure for the pipeline without leakage and shall leave the inside of the line free of any obstruction that can reduce its capacity below design requirements. Gaskets shall be installed according to the recommendations of the pipe manufacturer.

All fittings, such as couplings, reducers, bends, tees, and crosses, shall be installed according to the pipe manufacturer's recommendations.

Fittings and appurtenances made of unprotected steel or metals susceptible to corrosion shall be adequately protected by wrapping them with plastic tape or applying a coating having high corrosion preventing qualities. If plastic tape is used, all surfaces shall be thoroughly cleaned and coated with a primer compatible with the tape before wrapping them.

On buried pipelines where cathodic protection is required, high-resistance joints between pipe lengths shall be electrically bridged with a welded, brazed, or soldered copper wire not smaller than 4/0 gauge. After the joints are welded, they shall be covered with a coating equal in quality to that specified for the pipe. Dielectric connections shall be placed as specified on the drawings.

Cathodic protection. Buried pipelines shall be protected with sacrificial galvanic anodes if they are specified to supplement the protection provided by the pipe coating. The anodes shall be of the kind and number specified for the job or as shown on the drawings, or both. Anode materials shall be as specified under "Materials."

Anodes shall be placed as shown on the drawings and shall be bedded in moist clay, clay loam, loam, silt loam, or silt. In sandy and gravelly areas, fine material must be imported for bedding and for covering the anodes to a depth of 6 in. The packaged anodes and the fine textured soil used for bedding and backfill shall be thoroughly wetted.

Testing station facilities shall be located and installed as specified for the job, as shown on the drawings, or both. Wires at testing stations shall be attached to the pipe by one of the processes specified for anode lead wires.

Testing. Underground pipelines shall be tested before placing the backfill over the field joints. Aboveground pipelines may be tested at any time after they are ready for operation. Any joints that are leaking more than acceptable for that type of joint shall be repaired.

It shall be demonstrated that the pipeline will function properly at and below design flow.

Materials

Appurtenances. Standard fittings shall be used for the pipe. Elbows, tees, crosses, reducers, gate valves, check valves, air-and-vacuum-release valves, and pressure-relief valves shall be of the size and material specified or as shown on the drawings. Steel supports and saddles shall be constructed of material that equals or exceeds the requirements specified in ASTM A 36, "Structural Steel."

Pipe. Seams of pipe shall be welded or sealed. Helical pipe shall have annular ends. Pipe shall equal or exceed the requirements specified in one of the following standards:

ASTM A 760 Pipe, Corrugated Steel, Zinc-Coated

Fed. Spec, WW-P-402C Pipe, Corrugated (Aluminum Alloy (Amendment-1))

Fed. Spec. WW-P-405B Pipe, Corrugated (Iron or Steel, Zinc Coated (Amendment-1))

AASHTO M 36 Zinc Coated (Galvanized) Corrugated Iron or Steel Culverts and Underdrains

AASHTO M 196 Corrugated Aluminum Alloy Culverts and Underdrains (Amendment AASHTO M 196)

AASHTO M 245 Pre-coated, Galvanized Steel Culverts and Underdrains

AASHTO M 274, Steel Sheet, Aluminum Coated (Aluminized Type II) by the Hot Dip Process for Sewer and Drainage Pipe

Coating. If an interior and/or exterior coating is required, the coating shall meet the requirements of either Federal Specification WW-P-405B, Pipe Corrugated (Iron or Steel, Zinc-Coated (Amendment-1)), AASHTO M 190-78, Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches (Amendment M 190-80I), or AASHTO M 246-74 Pre-coated, Galvanized Steel Sheets for Culverts and Underdrains.

Paint. Paint shall meet the Federal Specification TT-P-641G, Primer Coating, Zinc Dust-Zinc Oxide (for galvanized surfaces).

Anodes. Zinc anodes must meet or exceed the requirements specified in ASTM B 418, "Cast and Wrought Galvanic Zinc Anodes for use in Saline Electrolytes."

Each anode shall have a full length core with a single strand of insulated copper wire solidly attached to it. The wire shall be No. 12 or larger. If a header wire is used, the gage must be adequate to carry the design current with no more than a 20-mV IR drop.

All anodes shall be commercially packaged. The packaged backfill mix shall be of the following proportions by weight.

Zinc ..... 20 to 30 pct bentonite: 70 to 80 pct gypsum
Magnesium ..... 20 to 25 pct bentonite: 70 to 75 pct gypsum: 5 pct sodium sulfate

Connection bands. Bands or couplers shall either meet the federal, ASTM, or AASHTO specifications detailed under "Pipe" except no flange (channel), smooth slab, or dimpled band shall be used. The selected band must provide a water tight joint.

Gaskets. Gaskets shall meet the requirements of ASTM C 443-79, Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.